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Search for UHE Emission from Cygnus X-3

The CYGNUS Collaboration

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ABSTRACT

Data from the CYGNUS experiment has been searched for evidence of ultra high energy (UHE) emission from Cygnus X-3. An upper limit to continuous flux from the source is given. In addition, we find no evidence for episodic emission from Cygnus X-3 on any time scale from 3.3 minutes to 4 years. The results of searches for periodic emission from Cygnus X-3 will be presented at the conference.

1. INTRODUCTION

Early observations of Cygnus X-3 in cosmic ray data provided the hope that the nature of UHE radiation from this and similar sources could be studied regularly (Samorski & Stamm 1983, Lloyd-Evans *et al.* 1983). These initial observations indicated UHE emission from Cygnus X-3 modulated by the 4.8 hour orbital period the binary system. However, more recent observations have been unable to confirm the existence of such emission.

On the other hand, several groups have reported evidence for episodic emission from Cygnus X-3 (Alexeenko *et al.* 1987, Tonwar *et al.* 1990, Bhat *et al.* 1990). Others have indicated evidence for a 12.6ms periodicity in the energy regime above $\sim$1 TeV, presumeably associated with the rotation of the neutron star (Gregory *et al.* 1990, Bowden *et al.* 1992).

In this paper, we present the results of searches for unpulsed, UHE emission over various timescales. We are currently examining our data set for signals which exhibit 4.8 hour and 12.6ms periodicity, and will report on these results at the conference.

2. THE CYGNUS EXPERIMENT

The CYGNUS extensive air shower array is located at the Los Alamos National Laboratory in Los Alamos, New Mexico. The array is at a latitude of 35.9°N, ideally suited to observe Cygnus X-3, as it passes near zenith during its transit. In 1986 the CYGNUS array began operation with 50 scintillation counters covering an area of $7 \times 10^3 \mathrm{m}^2$. There have been several upgrades to the experiment since 1986 which are described in detail elsewhere (Alexandreas *et al.* 1992). The current CYGNUS-I array consists of 108 scintillation counters deployed over an area of $2.2 \times 10^4 \mathrm{m}^2$. The median energy for gamma-rays triggering the detector is estimated to be ~ 70 TeV. The CYGNUS-I array has collected over 3.5×10^8 events as of this date.

3. CONTINUOUS AND EPISODIC EMISSION

We have searched for evidence of continuous, unpulsed, UHE emission using data taken between April,1986 and January, 1993. The number of events falling within an angular bin 2° in declination by 2.6° in right ascension, centered on Cygnus X-3, is compared with the number expected from background. The background level is determined by a Monte Carlo integration of the measured rate distribution for background events, as described by Alexandreas *et al.* (1993b, 1993c). No evidence for emission is found. The upper limit to the continuous flux at the 90% C.L. is $4.0 \times 10^{-14} \mathrm{cm}^{-2} \mathrm{s}^{-1}$ above 70 TeV.

A search for emission during a single transit of the source has also been performed. The most significant day occurred on January 27, 1987 (Julian day 2446823). 18 events were observed in the source bin when 5.6 were expected, yielding a 3.86σ result. After accounting for the number of days examined, the post-trial chance probability for this episode is 12%, consistent with fluctuations in the level of background cosmic rays.

Applying a technique developed to search for episodic emission of various durations (Biller 1992, Alexandreas *et al.* 1993d), we have also searched for a single burst of emission on time scales between 2 days and 4 years. The single most significant multi-day episode occurred during 2 days beginning on January 27, 1987. This is coincident with the single most significant transit given above, clearly demonstrating that these tests cannot be considered independent. During the 2-day episode, 27 events were observed in the source bin when 11.2 were expected. After accounting for the different intervals and time scales searched, the probability for this episode to have resulted from a fluctuation of the background level is estimated to be 54%. The same method was also applied to search for short-term emission. For each source transit, the chance probability for the most significant burst, over time scales ranging from 3.3 minutes to 1 day, is computed. The integral distribution of these burst probabilities is shown in figure 1. No significant deviation from the distribution expected due to fluctuations in the background level (dashed line) is seen. The post-trial chance probability for the single most significant short-term burst is 84%.

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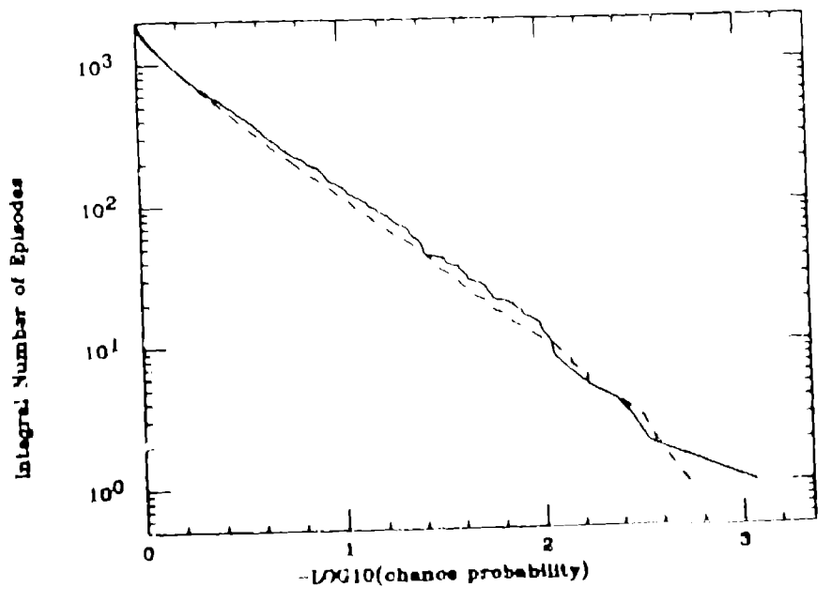

Figure 1. The integral distribution of burst probabilities for data associated with Cygnus X-3 corresponding to a range in time scales of 3.3 minutes to 90 minutes. The data spans the period between April, 1986 and January, 1993. The dashed line shows the expected distribution due to fluctuations in the background level.